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APPLICATION FOR LETTERS PATENT

TITLE: AM RECEIVER

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Description

The present invention relates to an AM receiver and a method of receiving and processing AM signals, in particular to such AM receivers which comprise an IF filter with a fixed IF bandwidth such as shortwave AM receivers with analog IF filters, in particular receivers for the Digital Radio Mondial (DRM) system.

In the DRM system an IF bandwidth of 20 kHz is mandatory for receivers. Therefore, the analog IF filters within a receiver must have a 20 kHz bandwidth. On the other hand, a DRM signal and the existing analog signal which should also be processable in a DRM receiver might also have only a useful bandwidth of 10 kHz or even less, like in case of the existing analog AM signal.

A problem raises if adjacent to such a wanted signal having a smaller bandwidth than the analog IF filters in a receiver an unwanted signal occurs, in particular if such a signal has a high level, since this signal which will not be suppressed by the analog IF filter leads to a wrong setting of the amplification factor of the following automatic gain control (AGC) circuit and therewith a desired resolution of the wanted signal part can not be obtained during an A/D-conversion which is performed after the AGC and before the digital baseband processing.

Fig. 3 shows such an AM signal and characteristics of the IF analog filters for two different IF frequencies, namely f_{IF1} as center frequency of a first analog filter which is obtained after a first downconversion from RF to IF1 and f_{IF2} as center frequency of a second analog filter which is obtained by a second downconversion from IF1 to IF2.

The left hand side of Fig. 3 shows the signal after the first downconversion. It is shown that the first IF analog filter has a passband of 20 kHz, i. e. the passband of the first IF analog filter has the range of f_{IF1}-10 kHz to f_{IF1}+10 kHz. The AM signal which is downconverted to IF1 comprises a wanted signal part 30 having a bandwidth of 10 kHz and a center frequency $f_C = f_{IF1}$, i. e. the frequeny range of the AM signal in the first IF stage is f_{IF1}-5 kHZ to f_{IF1}+5 kHz. Adjacent to this wanted signal part 30 are unwanted signal parts 31a, 31b having smaller, equal or higher levels in comparison to the wanted signal part 30. In particular a low frequency low level unwanted signal part 31a and a high

frequency high level unwanted signal part 31b are shown. These unwanted signal parts 31a, 31b lie within and outside the passband of the first IF analog filter.

The same is shown in the right hand side of Fig. 3 for the second IF stage with the center frequency f_C of the wanted signal part 30 equal to f_{IF2}, the bandwidth of the wanted signal part 30 equal to 10 kHz, namely from f_{IF2}-5 kHz to f_{IF2}+5 kHz and a 20 kHz bandwidth of the second IF analog filter, namely from f_{IF2}-10 kHz to f_{IF2}+10 kHz. Also in this case the unwanted signal parts 31a, 31b lie adjacent to the wanted signal part 30 and have respective levels below, equal to and higher than the level of the wanted signal part 30.

In such a constellation that a high level unwanted signal part 31b occurs adjacent to the small bandwidth wanted signal part 30 the energy of the wanted signal after an automatic gain control stage arranged behind the second IF analog filter might be much lower than without the unwanted signal part 31b at the input of a following A/D-converter.

To cope with this problem, either the resolution or the sampling clock of the A/D-converter must be increased so that within the following digital baseband processing a desired resolution of the wanted signal part can be achieved which leads to a higher cost for the realization of the receiver.

It is the object underlying the present invention to provide an improved AM receiver and method for receiving/processing an AM signal.

This object is solved by an AM receiver according to independent claim 1 and a method to receive/process an AM signal according to independent claim 9. Respective preferred embodiments thereof are defined in the following dependent subclaims, respectively.

According to a preferred embodiment of the present invention the frequency of the first downconverter which shifts the center frequency of the wanted signal part from RF to the first IF frequency IF1 is detuned in a way that a e.g. high level unwanted adjacent signal part lies outside the range of the first analog IF filter which is arranged behind said first downconverter.

Therewith, according to the preferred embodiment of the present invention the first downconverter cuts-off an unwanted signal part adjacent to the wanted signal part and based on the obtained signal the following AGC stage automatically sets a correct amplification factor so that the desired resolution of wanted signal part can be obtained during the A/D conversion.

The re-adjusting of the original center frequency can be done in the digital baseband processing or during the second down conversion to the second IF frequency IF2.

The best setting for such a "variable" first intermediate frequency IF1 can be obtained by analyzing the power of the FFT carriers outside the wanted signal part or by BER (Bit Error Rate) fine tuning in the digital baseband processing or by optimizing the AGC control voltage.

Of course, such a detuning can also be performed during the second downconversion or during the first and the second downconversion. In the latter case it is also possible to cut-off unwanted signal parts on both sides of the wanted signal. In both cases the re-adjusting of the original center frequency has to be done in the digital baseband processing.

In the following the present invention is illucidated by an exemplary embodiment thereof with reference to the accompanying drawings, wherein

Fig. 1 shows a DRM-receiver according to the present invention;
Fig. 2 shows IF signals in the receiver shown in Fig. 1; and
Fig. 3 shows IF signals in a receiver according to the prior art.

Fig. 1 shows a DRM-receiver according to the present invention. An AM signal is received by an antenna 1 and after amplification 2 the AM signal having a wanted signal part 30 with a center frequency f_{RF} gets downconverted by a first downconverter 3 so that the center frequency of the wanted signal part equals to f_{IF1}, namely to the first intermediate frequency IF1. After passing through a first IF analog filter 6 the received and downconverted AM signal gets further downconverted by a second downconverter 7 so that the center frequency f_{C2} of the wanted signal part equals to f_{IF2}, namely to the second intermediate frequency IF2. The resulting signal is filtered in a second IF analog

filter 9 before amplification in an automatic gain control unit 10, A/D-conversion by an A/D-converter 11 and a following digital baseband processing 12. Basically, this processing is in conformity with that of a conventional DRM receiver.

However, according to the described preferred embodiment of the present invention the first intermediate frequency f_{IF1} is not fixed like in the receiver according to the prior art, but can be detuned from the possible frequency of 10,7 MHz so that a high frequency high level unwanted signal part 31b or a low frequency low level unwanted signal part 31a within the AM signal lies outside the filter range of the first IF analog filter 6. Therefore, according to the preferred embodiment of the present invention a PLL circuit 4 adjusts the output frequency of a first fixed oscillator 5 so that its output frequency f_{LO1} which is input to the first down-converter 3 determines the appropriate first intermediate frequency f_{IF1} based on a control signal which is supplied from the digital baseband processing stage 12.

The detuning of the first intermediate frequency gets corrected during the digital baseband processing 12. Therefore, the downconversion to the second intermediate frequency, the second analog filtering, the automatic gain control and the A/D-conversion in-between the first intermediate frequency filering 6 and the digital baseband processing 12 is performed like in the DRM-receiver according to the prior art. Since according to the shown preferred embodiment of the present invention the first IF analog filter 6 cuts-off the high frequency high level unwanted signal part 31b and the low frequency unwanted signal part 31a basically has a level equal to the level of the wanted signal part 30, the energy of the wanted signal part 30 after the AGC 10 has an appropriate level and is not lowered or raised due to unwanted signal parts 31a, 31b with a level deviating from that of the wanted signal part 30.

As is apparent from the foregoing description, the first intermediate frequency f_{IF1} can be detuned to either be higher or lower than the first intermediate frequency in a DRM-receiver according to the prior art so that a high or low level unwanted signal part 31a, 31b adjacent to the wanted signal part 30 lying on either one side of the wanted signal part 30 can be cut-off.

However, if the second intermediate frequency f_{IF2} is also made variable by a second PLL circuit receiving the output frequency f_{LO2} of the second fixed os-

cillator 8 and supplying it to the second down-converter 7 it is also possible to cut-off unwanted signal parts on both sides of a wanted signal part, e.g. the low frequency unwanted signal part 31a can also be cut-off, in this case by the second IF analog filter 9.

Alternatively, in this case, the second down-converter 7 can also be used to set the predetermined second IF frequency f_{IF2} to the same frequency as used in the DRM-receiver according to the prior art. In this case no frequency correction has to be performed during the digital baseband processing 12.

Fig. 2 shows the downconverted AM signal in the first and second IF stages together with the filter characteristics of the first and second IF analog filters 6 and 9. In comparison to Fig. 3 the center frequency f_{C1} of the wanted signal part 30 is not set to f_{IF1} which is the center frequency of the first IF analog filter 6, but offset by Δf_{LO1} therefrom so that the high frequency high level unwanted signal part 31b is shifted to have a higher frequency to lie substantially outside the passband of the first IF analog filter 6. Since this high level high frequency unwanted signal part 31b is cut-off by the first IF analog filter 6 the automatic gain control 10 can shift the level of the wanted signal part 30 to an appropriate level for the following A/D-conversion 11. Further, since in this embodiment the second down-converter 7 is triggered by the second fixed oscillator 8 directly no further frequency shift is introduced and the center frequency f_{C2} of the wanted signal part 30 in the second IF stage is offset from the center frequency f_{IF2} of the second IF analog filter 9 also by Δf_{LO1}.

As discussed above, since the high level high frequency unwanted signal part 31b is substantially cut-off by the first IF analog filter 6 the center frequency f_{C2} of the wanted signal part 30 could be shifted to the appropriate second intermediate frequency f_{IF2} or further be offset to the low frequency side to cut-off the low frequency low level unwanted signal part 31a.